

CENTER HARBOR BAY
LAKE WINNIPESAUKEE
LAKES LAY MONITORING PROGRAM
1986

Freshwater Biology Group (FBG)
University of New Hampshire
Durham

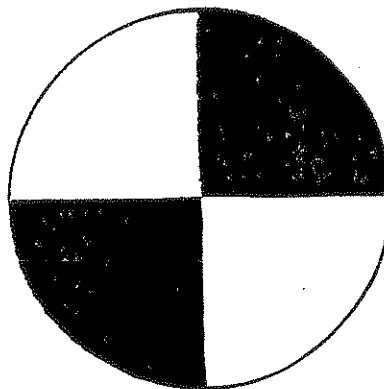
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LAKES LAY MONITORING PROGRAM

To obtain more information about the Lakes Lay Monitoring Program (LLMP) contact the LLMP Coordinator (J. Schloss) at (603)-862-3848, Dr. Baker at 862-3845 or Dr. Haney at 862-2106.

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ACKNOWLEDGEMENTS

This was the first year of participation in the Lakes Lay Monitoring Program (LLMP) for the Center Harbor Bay Conservation Commission. The Lay Monitor Contact is Mr. Duke Kline. We encourage Mr. Kline and other interested members of the Conservation Commission to continue monitoring during the 1987 season.

The Freshwater Biology Group (FBG) is co-supervised by Dr. Alan Baker and Dr. James Haney. Members of the FBG summer field team included Tracy Kenealy, Jeff Schloss, Patricia McCarthy, Lori Sommer, Steve Thomas and Zhanyang Guo. Tracy and Jeff shared coordination of the program and were responsible for arranging the field trips, training lay monitors, and supervising the research team. Patricia and Lori were responsible for the preparation of chemical solutions, chlorophyll analysis and data entry. Steve was responsible for phosphorus chemistry and analysis. All team members participated in field work and chemical analyses. In the fall, Alice Hibberd assisted in data organization and data entry and Jeff continued as LLMP Coordinator responsible for data interpretation and report writing.

The FBG would like to thank the University of New Hampshire Undesignated Gifts Committee for the partial funding of the coordinator position. Eileen Wong of the Department Zoology provided accounting and secretarial

service. The Department of Botany and Plant Pathology provided lab and storage space. We would also like to recognize the UNH Office of Computer Services for the provision of computer time and data storage space.

Participating groups in the LLMP for 1986 included: The New Hampshire Audubon Society, Derry Conservation Commission, Nashua Regional Planning Commission, Center Harbor Bay Conservation Commission, Governor's Island Club Inc., Little Island Pond Rod and Gun Club, Walker's Pond Conservation Society, United Associations of Alton, the associations of Baboosic Lake, Beaver Lake, Berry Bay, Bow Lake Camp Owners, Lake Chocorua, Flint Pond, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Moultonbouro Bay, Lake Winnepesaukee, Naticook Lake, Newfound Lake, Nippo Lake, Scruton Pond, Silver Lake (Hollis), Silver Lake (Madison), Squam Lake, Sunset Lake, Lake Winona, and Lake Wentworth and the towns of Alton, Amherst, Hollis, Merrimack and Strafford.

PROGRAM DESCRIPTION

The Lakes Lay Monitoring Program

The New Hampshire Lakes Lay Monitoring Program (LLMP) is a research and educational function of the Freshwater Biology Group (FBG) at the University of New Hampshire co-directed by Professors Alan Baker, Department of Botany and Plant Pathology, and James Haney, Department of Zoology and coordinated by Jeffrey Schloss. The program involves the cooperative participation of lake residents, lake associations, conservation and planning commissions and local governments with University faculty and students. Developed in 1978 around Squam Lake, the program has grown to include more than 30 lakes throughout New Hampshire.

As a research project, the LLMP has investigated the extent of lake degradation caused by perturbations such as acid rain, septic and agricultural runoff, and lakeshore development. Essentially the monitors in the program collect data once each week. The data are stored on a computer, the results are analyzed periodically, and interpretive reports are written that include graphics and statistical analyses. A major goal is to detect any short or long-term changes in the water quality of the lakes. To that end a long-term data base has been established.

As an educational tool, several students are trained each year to collect and analyze lakewater samples for physical, chemical and biological parameters, and to interpret water quality data. In addition, more than 200 "lay" monitors have been trained to monitor their own lakes and educated about lake water quality.

As a service to the state and to local communities, the reports of the LLMP are available at cost, and should prove useful to lake residents, conservationists, developers and land-use planners. Also, LLMP staff members conduct workshops, lectures and informal talks on various lake related topics and hold advisory positions on many municipal and private conservation and planning boards. The LLMP is a not-for-profit organization with funding derived primarily from the participating groups.

COMMENTS AND RECOMMENDATIONS

1) We recommend that each association, including the Center Harbor Conservation Commission continue to develop their data base on lake water quality through continuation of the long term monitoring program. The data base will provide information on the short and long-term cyclic variability that occurs in the lake and eventually will enable more reliable predictions of water quality trends. The database was initiated in 1986 but no monitoring by lay persons was undertaken in 1986.

2) We recommend phosphorus testing to be taken during the summer months. As early as possible for the initial sampling combined with sampling of the lake during a times of heavy use (ie: 4 July, Labor Day) or late in the season when septic systems have been put through a full seasons use.

3) The FBG trip provided a more in-depth analysis of the lake during early late summer conditions. We recommend one or more FBG trips in 1987.

4) We invite the Center Harbor monitors to participate in our preliminary investigation of the effect of boat traffic on lakes. All that would be required is sampling in the morning and late in the afternoon on a "quiet day" followed by the same sampling approach on a day of heavy boat traffic. A discount for sample processing will be offered to

try to minimize costs of additional testing. Contact the coordinator for further information.

5) As a general addition to our Lakes Lay Monitoring Program, we recommend that each lake in the Program begin monitoring the condition of the fish taken from the lake. The "Fish Monitoring" will require at least one lay monitor to record the species, length and weight and collect a sample of fish scales for each fish examined. In most lakes this will involve periodic creel census of sport fishermen on the lake. The required equipment, supplies and analytical costs will be approximately \$100. Explanation of procedures and fish identification will be given to monitors who decide to measure this parameter.

Length-to-weight ratios give a measure of the nutritional condition of the fish. Age analysis of the fish scales (to be done at UNH) will tell how old each fish is. Together, these variables can help to track changes in the condition of the fish populations in the lake, and, of course, the "health" of the lake.

INTRODUCTION

Importance of long term monitoring

A major goal of this program is to identify any short or long-term changes in the water quality of the lakes. Of major concern, is the detection of cultural eutrophication; increases in the productivity of the lake due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern since New Hampshire receives large amounts of acid precipitation. Weekly sampling of a lake during a single summer provides information only on the variation that occurs. Short-term differences may be due to variations in weather or lake activity, or other chance events. The resulting short-term fluctuations may be unrelated to the actual long-term trend.

As an example, a 30 year study of a lake may indicate a long-term trend toward eutrophy (Fig. 1). Yet if only the data from a five year period (ie: Fig 1, years 1975-80) are examined, no apparent trends can be seen. If only two years are examined, the data suggest a decrease in eutrophy! Monitoring carried out weekly over the course of many summers can provide the information required to distinguish between short-term fluctuation ("noise") and long-term

trends ("signal"). To that end, each lake must establish a long-term data base.

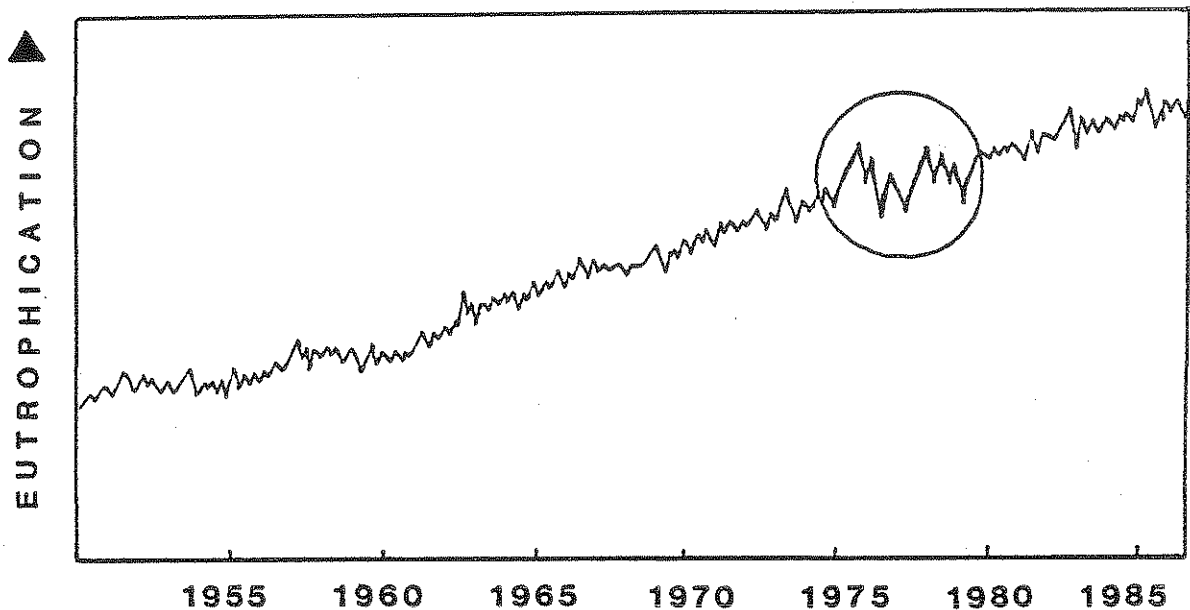


Figure 1. Eutrophication of a hypothetical lake over time. Circled area is enlarged for comparison between short and long-term trends.

The number of seasons it takes to discern between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. As more data is collected prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of the lake.

There are also short-term uses for lay monitoring data. The examination of different stations in a lake can disclose specific problems and corrective action can be initiated to handle the situation before it becomes more serious. On a lighter note, some associations post their weekly data for use in determining the best depths for finding fish!

It takes a considerable amount of effort as well as a deep concern for one's lake to be a lay monitor. Many times a monitor has to brave inclement weather or heavy boat traffic to collect samples. Sometimes it even may seem that one week's data is just the same as the next. Yet every sampling provides important information on the variability of the lake.

Every data sheet the LLMP receives is significant to further the understanding of the lakes in the program. We are pleased with the interest and commitment of our lay monitors and are proud that their work is what makes the LLMP the most extensive, and we believe, the best volunteer program of its kind.

METHODS OF THE FRESHWATER BIOLOGY GROUP

The Freshwater Biology Group (FBG) research team took one trip to Center Harbor Bay and conducted several tests which included measurements of sunlight penetration into the water, dissolved oxygen, temperature, alkalinity, free (unbound) carbon dioxide, pH, specific conductivity, chlorophyll a, dissolved color, total phosphorus, and a survey of the microscopic plants (phytoplankton) and animals (zooplankton). The input, storage and analysis of all LLMP data is also the responsibility of the FBG.

Field and Laboratory Methods

On the lake, a dissolved oxygen and temperature profile was taken using a Yellow Springs Instruments Model 54A Oxygen/Temperature meter with a submersible probe. Readings were taken at one-meter intervals throughout the epilimnion and hypolimnion, and at one-half meter intervals through the metalimnion.

Sunlight and skylight penetration into the water was measured with a Whitney submersible photometer model LMA-8A, off the sunny side of the boat. The coefficient of light extinction was calculated from the relative light intensities measured.

Water clarity was measured by lowering a secchi disk (approximately 20 cm. or 8 inches) through the water off the

shaded side of the boat, and noting the average of the depths at which it disappeared upon lowering and reappeared when being raised (the cord attached to the secchi disk is marked in one tenth of a meter for the first half meter and in one-half meters thereafter). Water clarity was determined while holding a view-scope just below the surface to eliminate effects of surface reflection and wave action. This was repeated two or three times, and an average to the nearest one-tenth of a meter was recorded.

Samples of lake water chemistry to be analyzed for dissolved oxygen, alkalinity, free (unbound) carbon dioxide, pH, and specific conductivity were collected with a 3-liter Van Dorn bottle at depths which represented the surface, mid-epilimnion, metalimnion, and hypolimnion. Alkalinity, free carbon dioxide, and pH samples were stored on ice in 250 milliliter polyethylene bottles and were analyzed in the field within 1 to 2 hours of sampling. Specific conductivity samples were analyzed in the FBG lab at room temperature.

In addition to the oxygen profile taken, the dissolved oxygen (DO) concentration of specific lakewater samples (epilimnetic and hypolimnetic) were determined chemically with the azide modification of the Winkler method (EPA 1979). The precision of the method provides a standard for the electronic probe. Water is collected in 350 ml biological oxygen demand (BOD) bottles and fixed with two

reagents, manganese sulfate and alkali-iodine-azide. A loose precipitate (floc) of manganic hydroxide is formed that is equivalent to all dissolved oxygen originally present in the sample. Concentrated sulphuric acid is added to the bottle which causes a stoichiometric release of dissolved iodine equal to the original amount of dissolved oxygen present. A known quantity of sample is then titrated to an equivalence point using .0250N phenylarsine oxide titrant (similar to, but more stable than, sodium thiosulphate which may also be used) and a starch indicator solution. The end-point is reached when the purple colored iodine-starch complex is reduced and the solution becomes colorless. The amount of titrant added is recorded to the nearest 0.1 ml and concentrations are reported to the nearest 0.2 milligrams dissolved oxygen per liter.

To determine the alkalinity, lake water samples were titrated with 0.002 N sulphuric acid in the presence of the indicator methyl red/bromocresol green to a pH of 5.1 (grey endpoint) and 4.6 (pink endpoint). The amount of titrant used (dilute sulphuric acid) was recorded to the nearest 0.1 ml, equivalent to milligrams of calcium carbonate per liter. Values reported can be converted to microequivalents of calcium carbonate using a multiplication factor of 20.

"Free" carbon dioxide concentration was determined by titrating the fresh lakewater samples with 0.0027 N sodium

hydroxide to a final endpoint pH of 8.3, in the presence of the indicator dye phenolphthalein.

Lakewater pH was measured with a digital pH meter (Beckman model phi 44) equipped with a combination probe (Orion Co.) and an automatic temperature compensating probe. The meter was calibrated with pH 4 and pH 7 buffer solutions and then the probe was allowed to equilibrate in the lake water for at least thirty minutes prior to sample analysis.

Specific conductivity was measured with a Barnstead Conductivity Bridge Model PM-70CB , with a model B-10 probe (cell constant = 1.0). Corrections were made for sample temperatures with a standard curve of potassium chloride solution conductivity versus temperature. Results are reported as micro-Siemens (uS; where uS equals umho cm^{-2}) standardized to 18° C.

Samples to be analyzed for chlorophyll a, total phosphorus, and phytoplankton were collected with a vertical tube sampler into a 2.5 liter dark plastic bottle. Chlorophyll samples were filtered through a 0.45 micron membrane filter and air-dried in the dark until analysis. The chlorophyll a content was analyzed by extracting the chlorophyll with a 95% acetone solution saturated with magnesium carbonate. The samples were then centrifuged and their light absorbance read at two standard wavelengths (663 and 750 nanometers) with a Baush and Lomb model 710

spectrophotometer equipped with 50mm cuvettes. An absorptivity value of $84 \text{ gm liter}^{-1} \text{ cm}^{-1}$ (Vollenweider 1969) was used for calculating the concentrations.

Dissolved color samples of the filtrate from FBG and lay monitor chlorophyll filtrations was determined by reading the absorbance of the samples at two different wavelengths (440 and 493 nanometers) in a 50mm light path. The two readings were converted to the more widely used platinum cobalt color values (ptu) using standard curves of the absorbance of chloroplatinate.

Phosphorus samples were preserved with 1.0 milliliter of concentrated sulphuric acid and refrigerated until analysis. Also, phosphorus samples from lay monitors were received by the FBG in a refrigerated or frozen state, and stored cold until analysis. To determine the total phosphorus content, ammonium persulfate and 11 N sulfuric acid was added to digest the total phosphorus, and the samples were autoclaved for thirty minutes at 250 to 260 degrees C. Reagents included potassium antimony tartrate, ammonium molybdate, and a solution of ascorbic acid mixed fresh before each sample run (E.P.A. 1979). Absorbance of the blue phosphorus complex was measured with a spectrophotometer at 650 nanometers. A standard curve of the absorbance of a potassium phosphate (monobasic) solution to convert the readings to total phosphorus concentrations.

Each sample was analyzed twice and an average of the two values taken as the phosphorus content in parts per billion (ppb).

Phytoplankton samples were preserved with iodine (Lugol's solution) immediately after collection. Algae were later identified and counted with an inverted microscope after settling for 24 hours in 5 or 10 ml counting chambers. At least 200 individual algal "units" were counted with a modified scan technique (Baker, 1973). Phytoplankton are reported to species level whenever possible.

Zooplankton samples were collected with a plankton net (30 centimeter diameter, 150 micron porosity) towed vertically through the oxygenated portion of the water (>0.5 ppm oxygen). Samples were immediately preserved in a 4% formalin-sucrose solution (Haney and Hall, 1973). Organisms were identified to species whenever possible. Subsampling, whenever necessary, was done with a 1 ml Hensen-Stemple pipette. Repeated subsamples were analyzed until at least 100 organisms were counted.

Data analysis

Incoming data are received through the mail during the sampling season and are first filed in an "incoming data" book. This provides temporary storage until the corresponding chlorophyll and/or phosphorus sample for each data sheet is analyzed. All data, including date, lake,

site, secchi disk depth, chlorophyll a and phosphorus concentrations, alkalinity, and color measurements, are filed and stored on the FBG computerized data-management system that utilizes a mainframe DEC VAX-8650 computer and an IBM compatible microcomputer (Zenith Data Systems 158). With full use of relational data bases, such as S1032 and Dbase III+ data can be easily retrieved by lake, date, station or by parameter and used for individual reports and program summaries for each year.

Statistical treatment of the data from each lake, produced for level III reports, includes a comparison of seasonal tendencies found throughout the year, monthly means for the different parameters tested, and confidence levels for each site. The same comparisons are made on a yearly basis if the lake has been in the program for two years or more. Where sufficient data are available from several years, regression analyses and other statistical tests can be performed. Such analyses may identify trends and help explain variations in the data (eg. secchi disk depth, chlorophyll a, color). In addition, data from a lake may be compared with other lakes in the program, other computerized data bases (New Hampshire Water Supply and Pollution Control, New Hampshire Fish and Game, EPA Surface Water Survey and others) and to published water quality classifications.

Trophic boundaries of Forsberg and Ryding (1980) of transparency, chlorophyll a, and total phosphorus are used as criteria in discussions of the trophic state of the program lakes. Phytoplankton are reported both as species and classes. Crustacean zooplankton were classified into one of four categories depending on their size (large or small) and their feeding preferences (herbivore or predator) with a modified version of criteria from Sprules (1980). The differences in abundance between the different groups allow for a more complete description of the zooplankton community and the trophic classification of lakes.

RESULTS AND DISCUSSION OF FBG DATA

Sampling of Center Harbor Bay by the FBG field team took place on 19 June at site 1 Center. This site is located mid-bay over approximately 11 meters of water.

Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of secchi disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

The water transparency of Center Harbor was 6.2 meters. Generally speaking, a value of 4 or greater is common for less productive, clear lakes.

Chlorophyll a

The chlorophyll a concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large amounts of algae and aquatic plants due to nutrient enrichment. **Oligotrophic** lakes have low productivity and low nutrient levels and **mesotrophic** lakes are intermediate in productivity.

Chlorophyll concentration in June 1986 was moderate, 3.5 mg m⁻³. Values greater than 3.0 mg m⁻³ are common to more productive (mesotrophic) systems.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from humic substances, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters.

Dissolved color was low at site 1, 1 ptu. To put the color level in perspective, dissolved color concentrations of all lakes participating in the LLMP in 1986 were in the range <1 to 117 ptu with an average of 18.5. Thus, Center Harbor color was below average compared to all lakes in the program.

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources primarily originate from

anthropogenic activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton.

Phosphorus concentration on 16 July was 19 ppb at site 1. Concentrations of total phosphorus greater than 15 ppb are common in mesotrophic lakes.

Specific Conductivity

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and de-icing salt runoff from highways can cause high conductivity values. Conductivity values at Center Harbor in 1986 had a range of 139 to 141 uS suggesting that the bay is receiving road salt runoff and/or septic input near site 1.

Stratification in the Deep Water Site

Profiles of temperature for site 1 (see Figure 2) indicate the beginnings of the typical pattern of temperature stratification where a layer of warmer water (the epilimnion) overlies a deeper layer of cold water (hypolimnion). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the thermocline or metalimnion.

Dissolved Oxygen and Free CO₂

Oxygen concentration was high in the epilimnion and decreased to very low concentrations in the bottom waters (Fig. 2). The "blips in the oxygen profile may indicate depths where algae are layering. Future FBG trips should test for the presence of these layers. Carbon dioxide in bottom waters is low. Carbon dioxide is generated and can accumulate in aquatic systems as a result of the respiration of a wide variety of organisms in the water. Plants (including the phytoplankton) take up free carbon dioxide and produce oxygen during the day, but respire at night along with the aquatic animals and bacteria. Carbon dioxide usually accumulates in the bottom waters of more productive systems where large amounts of organic material, produced within and around the lake, support large bacterial populations. Breakdown of organic matter, respiration and fermentation by the bacteria in the water and sediments consumes oxygen and releases carbon dioxide. Increases in dissolved carbon dioxide result in the decrease of the lakewater pH.

pH

The pH is a way of expressing the acidic level of lake water, and is measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic

(ie: changes in 1 pH unit reflect an order of magnitude, ie: 10 times, difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

Surface pH was 7.1 at site 1. The range of surface water pH for all LLMP lakes was 5.2 to 7.2. The pH increased to 7.2 at 7 meters. with depth to 7.2 (Fig. 1). At present the pH of Center Harbor is within the optimum range of many aquatic organisms.

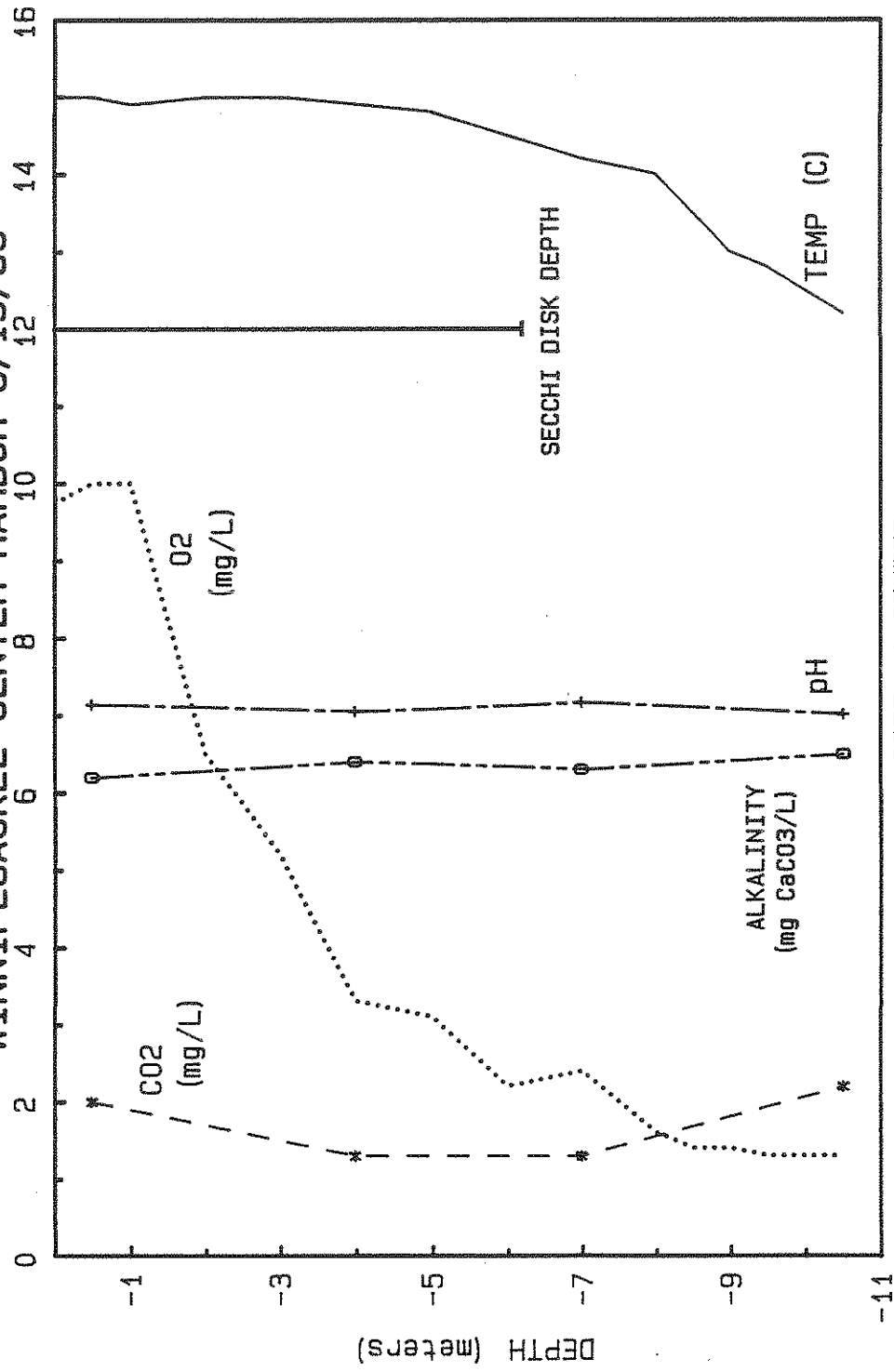
Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock of lake watersheds.

Surface alkalinity at site 1 was 6.2 mg CaCO₃ liter⁻¹ and increased to 6.4 mg CaCO₃ liter⁻¹ at 10.5 meters. Average alkalinity for three hundred New Hampshire lakes (1975-84) is approximately 9.0 mg CaCO₃ liter⁻¹ (New Hampshire Water Supply and Pollution Control). The average alkalinity of all LLMP lakes participating in 1986 was 6.2

Figure 1 - Profiles of temperature, dissolved oxygen (O₂), "free" carbon dioxide (CO₂), alkalinity and pH on 19 June 1986 at Center Harbor Bay, Lake Winnepesaukee, site 1 Center. Oxygen and temperature were measured at one-half meter intervals, other parameters were sampled at the discrete depths indicated by the o's, crosses and asterisks. Secchi disk depth is also indicated.

WINNIPESAUKEE CENTER HARBOR 6/19/86



SITE: 1 CENTER

mg CaCO_3 liter⁻¹. Thus, Center Harbor Bay alkalinity is low, but about average for lakes in the LLMP program.

Phytoplankton

Concentration of phytoplankton at site 1, low to moderate, 1854 organisms per ml. Flagellated forms dominated the composition of the plankton but a single date, early in the season, does not provide enough information for any firm conclusions. More data obtained in future FBG trips will allow for a better description of typical planktonic organisms present in the bay. The golden algae (Chrysophyceae) dominated with the colonial species Uroglenopsis in high numbers.

Zooplankton

The macrozooplankton (caught using a 150 micrometer mesh net; excluding copepod nauplii) in the oxygenated waters of site 1 numbered less than 10 per liter. This is a low value. Calanoid copepods were the dominant herbivores ("phytoplankton eaters"). The herbivorous cladoceran Bosmina was subdominant.

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